CHAPTER 9. INSPECTION

9-1.01 Introduction

The field engineer's role during the construction phase is one of inspection of the falsework as it is erected to ensure that construction is in accordance with the approved falsework drawings, that only sound materials are used and quality workmanship employed, and that all specific specification requirements are met. (However, keep in mind that inspection by the engineer does not relieve the contractor of his contractual responsibility for the falsework.)

Timely inspection is essential. Any noted deficiencies, such as construction which does not conform to the approved falsework drawings, poor workmanship, or the use of unsound or poor quality materials, should be brought to the contractor's attention at once. If the contractor fails to take corrective action, a confirming letter should be written. The letter should list the deficiencies that require remedial action but specific corrective measures should not be ordered, nor should any predictions be made.

9-1.02 Falsework Erection and Removal Plans

The specifications require the use of construction methods, including temporary bracing when necessary, to prevent the overturning or collapse of the falsework during each. phase of erection and removal. The means by which the contractor complies with this specification requirement is commonly referred to as the "erection" or "removal" plan.

Before falsework erection begins, the erection plan should be discussed with the contractor's field representative who will be responsible for supervising the erection work. The purpose of this policy requirement is to ensure that the erection plan is appropriate for the site and conditions to be encountered, and that all persons involved with the work (both contractor and State) are familiar with the erection plan.

A similar discussion with contractor personnel is required before the falsework is removed. (See Section 9-1.16, Falsework Removal.)

9-1.03 Foundation Pads and Piles

The specifications permit the contractor to set falsework pads and drive falsework piles before the falsework drawings are approved. However, in accordance with Division policy, pad placement and pile driving are to be inspected, to the extent necessary to ensure an adequate foundation, at the time the work is done, even though the drawings may not yet be approved.

9-1.03A Pad Foundations

Since pad design is based on anassumed soil bearing value, the foundation material should be inspected before the pads are set and a realistic soil bearing value assigned. Timely inspection is necessary to ensure that the assumed value does not exceed the actual soil bearing-value as determined by observation or soil load test.

Appendix B includes soil classification charts. for both sandy and clayey soils. These charts may be used to approximate the actual soil bearing value for a given soil.

To ensure uniform soil bearing, falsework pads must be level and set on material that provides a firm, even surface free of humps or depressions within the pad bearing area. If necessary to obtain uniform bearing, a thin layer of sand may be used to fill in surface irregularities.

When pads are set on material backfilled around piers and columns in stream channels or other locations where there are no specific compaction requirements, care must be taken to ensure that the backfilled material is sufficiently compacted to provide the required soil bearing value.

Benches in fill slopes should be cut into firm material, with the pad set back from the edge of the bench.

Continuous pads should be inspected to verify that joints are located as shown on the approved drawings.,.or if not so located, that the joint location meets Division of Structures criteria. (See discussion in Chapter 7.)

The soil bearing capacity of some soils is greatly reduced when the ground becomes saturated. To prevent loss of support, pad foundations should be protected from flooding and/or undermining from surface runoff, and the pad area should be self-draining.

9-l.03B Soil Load Tests

The specifications require the contractor, when requested by the engineer, to " ...demonstrate by suitable load tests that the soil bearing values assumed for the design of the falsework do not exceed the supporting capacity of the soil." (Standard Specification 51-1.06B, Falsework Construction.) Accordingly, the engineer should request a load test if there is uncertainty as to the ability of the foundation material to support the loads to be imposed.

Note that the specifications require suitable load tests. In the specification context, the term "suitable" is interpreted to mean static load tests that consider both settlement and duration of load, but which are simple in their application and thus may be performed by the contractor. Division policy does not require a sophisticated load test of the type that might be performed by a geotechnical testing facility or soils lab.

Appendix B includes general information and testing procedures for simple, static load tests to determine soil bearing values. Appendix B should be reviewed prior to the performance of any load test made to verify the adequacy of falsework foundation materials.

The Structures Foundation Unit at the Engineering Service Center in Sacramento is available for consultation and advice as to the suitability of a particular load test in a given field situation, as well as interpretation of test results.

9-1.03C Sand Jacks

Sand jacks, which consist of compacted sand physically confined within a timber or metal frame, are often used to facilitate falsework removal.

To prevent inadvertent settlement while a sand jack is still carrying a load, care must be taken to ensure that the sand will be protected from rain or flooding, or any other cause that might contribute to premature erosion of the sand. To ensure their integrity, sand jacks are normally constructed so the annular space between the top bearing plate and the side plates or frame does not exceed about l/4-inch.

9-1.03D Falsework Piles

Division policy requires the falsework pile driving operation to be inspected to the extent necessary to verify that the required bearing values are obtained.

The pile bearing value required to support the design load will be shown on the falsework drawings. Pursuant to specification requirements, bearing values for falsework piles are determined by the ENR pile driving formula. Use of the ENR formula and inspection procedures will be the same for falsework piles as for permanent piles, unless a drop hammer is used. The use of drop hammers is discussed in the following section.

If the falsework design includes timber pile bents, the design will be based on certain assumptions as to penetration, driving tolerances (i.e., maximum allowable pile pull and pile lean) and the ground line pile diameter, all of which should be shown on the falsework drawings. Timber pile bent designs require continuous inspection as the piles are driven to assure that the design assumptions are met. This is the case because pile penetration cannot be verified by observation after the pile has been driven, and the distance a given pile has been pulled cannot be determined once the pile is in its final position under the cap.[1]

Driving tolerances are particularly critical in pile bent designs. If little or no tolerance is permitted by the false-work design, this fact should be brought to the contractor's attention before driving begins.

9-1.3D(l) Drop Hammers

Although the specifications prohibit the use of drop hammers for permanent work, there is no similar restriction for piles used in temporary construction facilities. Accordingly, drop hammers may be used to drive falsework piles, as provided in this section.

Drop hammers must weigh at least 3000 pounds, and should be equipped with leads and hoisting equipment that is adequate to handle the work efficiently. The hammer fall-distance should not exceed about 10 feet.

For drop hammers, the ENR formula is:

$$P = \frac{2WL}{s+1}$$

where P is the safe load, in pounds; W is the weight of the hammer, in pounds; L is the hammer fall, in feet; and s is the penetration per blow, in inches, averaged over the last few blows.

Unless the hammer weight is clearly evident, the contractor should be required to substantiate the weight used in the bearing calculations.

[1] Chapter 7 includes a discussion of the assumptions that govern the design of timber pile bents, and their relative importance.

9-1.04 Timber Construction

Wood differs from other building materials in that it is organic in nature, nonhomogeneous, and composed of tube-like cells many times longer than they are wide. The cellular structure of wood fibers along with natural defects that develop as a tree grows are factors which result in a wide variation in the physical properties and characteristics of cut lumber. [2]

Timber falsework materials should be inspected for damage as they are delivered to the work site. Used timbers should be examined for evidence of mechanical damage, decay or distortion of shape, and defective or substandard pieces rejected.

Rough sawn timbers should be measured to determine their actual dimensions. Unlike surfaced material, the dimensions of rough-cut timbers are not uniform from piece to piece. The variation may be appreciable, particularly in the larger sizes commonly used for falsework posts and stringers. If the actual dimension is smaller than the dimension assumed in the design, the member may not be capable of carrying the intended load without over-stress.

9-1.04A Connections in Timber Framing

Connections in timber framing for falsework bents and similar locations where engineered connections are required shall be fabricated in accordance with industry guidelines as summarized in this section.

9-1.04A(l) Bolted Connections

End and edge distances are measured from the end or side of the wood member to the center of the bolt hole, and must be equal to or greater than the following minimums:

- For parallel-to-grain loading, the required end distance is 7 bolt diameters for members in tension and 4 bolt diameters for members in compression.
- For perpendicular-to-grain loading, the required end distance is 4 bolt diameters.
- For parallel-to-grain loading in tension or compression, the required edge distance is 1.5 bolt diameters.

---

[2] A comprehensive discussion of the physical properties and characteristics of wood as a structural building material may be found in Appendix A.

- For perpendicular-to-grain loading, the edge distance toward which the bolt is acting shall be at least 4 bolt diameters and the distance on the opposite edge shall be at least 1.5 bolt diameters. When stress reversal will occur, 4 bolt diameters are required at both edges.

The minimum spacing between two bolts in a row is 4 bolt diameters, measured center-to-center of the holes.

Bolt holes and installation must conform to the following:

- Bolt holes shall be a minimum of l/32-inch to a maximum of l/16-inch larger than the bolt diameter.

- Holes in the main and side members shall be aligned and the bolt centered in the hole. Tight fit requiring the forcible driving of bolts is not recommended industry practice.

- A washer or metal plate not less than a standard cut washer shall be placed between the wood and the bolt head and between the wood and the nut.

Design values for bolted connections apply to bolts that have been snugly tightened. To ensure adequate strength, connections should be inspected after the falsework is adjusted to grade, and bolts retightened if necessary.

9-l.O4A(2) Lag Screw Connections

As provided by industry guidelines, edge and end distances in lag screw connections must conform to the requirements for bolted connections made with bolts having a diameter equal-to the shank diameter of the lag screw used.

Lag screws shall be inserted in predrilled holes conforming to the following:

- The clearance hole for the shank shall have the same diameter as the shank, and the same depth of penetration as the length of unthreaded shank.

- The diameter of the lead hole for the threaded portion shall be between 60 and 75 percent of the shank diameter, with the larger percentage applying to lag screws having larger diameters.[3] The length of the lead hold shall not be less than the length of the threaded portion.

---

[3]The percentage range shown is for Douglas Firs Larch. For appropriate ranges for other wood species, contact the Office of Structure Construction in Sacramento.

Lag screws are to be inserted in the lead hole by turning with a wrench, not by driving with a hammer.

To facilitate installation, soap or other lubricant may be used on the screw or in the lead hole.

9-1.04A(3) Drift Pins and Drift Bolts

Drift pins and drift bolts are to be driven into predrilled holes having a diameter l/16 inch less than the diameter of the drift pin or drift bolt to be installed.

9-1.QA(4) Nails and Spikes

For nailed or spiked connections, the falsework drawings will show the number of fasteners required, but fastener placement usually is not detailed on the drawings. The industry guide-line is that end distance, edge distance and spacing must be sufficient to prevent splitting of the wood; however, the Division of Structures has established more specific guidelines to govern fastener placement for falsework on State highway projects. The Division's guidelines may be found in Chapter 4, Section 4-3, and should be reviewed before construction begins. Fastener placement for connections made with nails or spikes must conform to the Division's guidelines.

There are specific penetration requirements for nails and spikes, as shown in Tables E-4 through E-7 in Appendix E. In most cases obtaining the penetration required to develop the design value of a given fastener will not present a problem. However, when round posts are used or when longitudinal bracing on skewed bents is not parallel to the side of a square post, care must be taken to ensure that the penetration assumed in the design is actually obtained, since nails or spikes having less than the required minimum penetration will have no allowable load-carrying capacity.

9-1.04B Timber Workmanship Checklist

The following checklist may be used as a guide to points that warrant special consideration:

- Posts must be plumb and centered over the pad or corbel.

- Posts may be wedged at either the top or bottom for grade adjustment, but not at both locations.

- For larger post loads; the design will often provide for two or more sets of wedges (set side-by-side) to keep the perpendicular-to-grain compression stresses within the allowable. In some cases only one set will be installed initially, with the remaining set(s) installed after the falsework is adjusted to final grade. Such installations should be inspected after adjustment to grade, to ensure that all required wedges are in place.

- Particular attention should be given to falsework bents where grade adjustment is provided at the bottom of the posts. Since any differential vertical movement of posts within a bent may induce undesirable stresses into the frame, the diagonal bracing should be inspected after the falsework is adjusted to grade for evidence of deflected braces and/or distortion at the connections.

- Blocking should be kept to the minimum amount needed for erection and adjustment. It is poor workmanship to extend a short post by piling up blocks and wedges, since this can lead to a condition of instability.

- Full bearing must be obtained at all contact surfaces. Deficiencies in this respect may be improved by feather wedging; however, if the joint requires more than a single wedge, extra care should be taken to ensure that full bearing is obtained.[4]

- The ends of spliced posts must be cut square, with proper size splice plates, and nails must be of the proper size, pitch and edge distance.[5]

- Jacks used for grade adjustment must be plumb and not extended beyond the distance recommended by the jack manufacturer, and the load should be centered over the jack.

- Soffit plywood sheets should be set with the face grain perpendicular to the joists with abutting ends of the sheets supported on a common joist.

- Telltales should be attached to the joists, and located as close as possible to the supporting bent cap or post. The number of telltales used must be adequate to determine the settlement at any location over the entire falsework.area.

---

[4] Cedar shingles, which are occasionally used as wedges, should be used with caution since cedar has a significantly lower cross-grain strength than Douglas Fir or any of the commonly used hardwoods.

[5] The need for a post splice should have been anticipated and the proposed splice detail shown on the falsework drawings. If this is not the case, the contractor must submit a detail for approval. (See Falsework Memo C-8 for information on design of splices in timber posts, and an example problem.)

9-I.05 Structural Steel

Used beams, and particularly beams salvaged from a previous commercial use, should be examined carefully for loss of section due to welding, rivet or bolt holes, or mechanical damage (kinks or notches in flanges, etc.), all of which may reduce the load-carrying capacity of the beam.

If the falsework design is based on the higher working stresses allowed for grades of steel other than Grade A36, the contractor must furnish substantiating mill test reports and a Certificate of Compliance. The Certificate of Compliance shall be signed by the contractor, and shall list and describe the beams covered by the mill test reports.

9-1.05A Welded Splices in Falsework Beams

Occasionally, a longer steel beam will be fabricated by welding together two shorter beams of the same cross-section.

For spliced beams, if the welding is performed at the site or at a nearby location closely related to the work, such as the contractor's yard, the splices shall be made by full penetration butt welding of the entire cross section in conformance with applicable requirements in AWS D1.1, *Structural Welding Code -- Steel.*.

For previously welded beams, the splices should be visually inspected for obvious defects; however, radiographic inspection of other methods of nondestructive testing will not be required unless there is evidence of defective welding.

9-l.06 Manufactured Assemblies

The term "manufactured assembly" as it is used in the falsework specifications means any commercial product or device the use of which is governed, in whole or in part, by conditions or limitations imposed by the manufacturer. Typical manufactured assemblies include jacks, beam hangers, overhang brackets and similar commercial products, and all commercial shoring systems.

When a manufactured assembly is used in the falsework, the contractor must furnish a written certification stating that all components of the assembly are used in accordance with the manufacturer's recommendations. The certification may be signed either by the contractor or by the engineer (or representative) who signs the falsework construction certification required by the Construction Safety Orders. (See Section 9-1.13, Cal-OSHA Requirements.)

A separate certification is required for each product or device used in the falsework.

9-l.07 Metal Shoring Systems

The safe load-carrying capacity of all commercially available shoring systems is based on the use of new components, or used components in good condition, properly erected in conformance with the manufacturer's recommendations. Consequently, proper inspection is of particular importance to ensure-the adequacy of the completed system.

Shoring components should be inspected prior to erection. Any component that is heavily rusted, bent, dented or otherwise defective, should be rejected, as should any fabricated unit in which individual members are bent, dented, twisted or broken, or where the welded connections are cracked or shows evidence of rewelding.

A base plate, shore head or screw jack extension device should be used at the top and base of all tower legs. All base plates, shore heads or extension devices must be in firm contact with the footing at the base and the cap at the top.

Vertical components should fit together evenly, without any gap between the upper end of one unit and the lower end of the other unit. Base plates and shore heads or extension devices must fit into the tower legs. Any component that cannot be brought into proper contact with the component into or onto which it is intended to fit should not be used.

Shore heads and extension devices must be axially loaded, since shoring components are not designed to resist eccentric loads.

All locking devices on frames and braces must be in good working order. Coupling pins must bring the frame or panel legs into proper alignment, and pivoted cross-braces must have the center pivot in place.

Shoring must be plumb in both directions. Refer to technical data sheets issued by the manufacturer for the maximum allowable deviation from true vertical. If this deviation is exceeded, the shoring must be readjusted to meet the limit.

When a shoring system is used, the contractor must furnish a certification that the use of the shoring is in accordance with the manufacturer's recommendations. (See Section 9-1.06, Manufactured Assemblies.) Field engineers should keep in mind that this certification is a Standard Specification requirement, and is in addition to the falsework certification required by the Construction Safety Orders. (See Section 9-1.13, Cal-OSHA Requirements.)

When a commercial shoring system is used for falsework, review and approval of the design will be based on a particular system; i.e., WACO, PAFCO, etc. While the various systems have many similar components, they are not intended to be interchangeable between systems. Accordingly, field engineers should make certain that the *system* furnished is the system shown on the falsework drawings and further, that all system components are part of the approved system unless intermixing of components is authorized by all manufacturers whose components are used in the falsework, as discussed in the following paragraph.[6]

In any case where system components are to be intermixed, the contractor must obtain and furnish a letter of approval of such intermixing from each manufacturer whose system components are to be incorporated into the falsework. Each letter must state that the use of components from the other system(s) will not reduce either shoring capacity or the required safety factor. (For example, if PAFCO shoring is shown on the falsework drawings but some WADCO bracing components are to be used with the PAFCO shoring, the contractor must obtain letters from both PAFCO and WADCO expressly stating that such intermixing will not reduce the nominal capacity or safety factor of their system.)[7] The procedure discussed in the preceding paragraph assumes that most of the component elements of the shoring will be components of the system shown on the approved falsework drawings. If, however, the majority of the system components to be assembled and erected are not components of the system shown on the falsework drawings, this occurrence will be considered a de facto change in the falsework design which will negate the previous approval of the drawings. New or revised -drawings and technical data for the system actually intended for use must be submitted for review and approval before the shoring may be erected.

---

[6] The recently issued FHWA *Construction Handbook for Bridge Temporary Works* notes that there are no industry standards for the various components of proprietary shoring systems in use today, and concludes that components produced by different manufacturers should not be intermixed. Division of Structures policy recognizes that the manufacturers of the various systems are in the best position to evaluate the effect of intermixing system components, and permits such intermixing if approved by the manufacturers of the intermixed systems.

[7] Note that these approval letters are in addition to the certification required by the specifications, as discussed in Section 9-1.06, Manufactured Assemblies.

9-1.08 Miscellaneous Field Welding

Fillet welds in job-fabricated devices or installations of any kind, including bracing and connections, may be accepted on the basis of casual inspection, provided the design value of the fillet weld is not more than 1000 pounds per lineal inch for each l/S-inch of fillet weld.

For fillet welds requiring a higher design value, or for any connection or other installation requiring a butt weld, the welding must be performed in conformance with the requirements in AWS D1.1, *Structural Welding Code -- Steel.*

9-1.09 Powder Driven Nail Anchorages

Section 51-1.05, Forms, of the Standard Specifications permits the use of driven type anchorages to fasten forms to interior surfaces of girder stems in prestressed box girder bridges where the reinforcing steel clearance is 2 inches or more.

The specification contemplates the use of nails driven with low velocity powder driven hammers operated in accordance with the manufacturer's recommendations. Such powder driven nails have a shear value of 400 pounds, provided they are installed in conformance with the following criteria:

- Hammers must be perpendicular to the concrete surface when the nail is driven. Hammers are to be operated only by qualified persons possessing valid evidence (current card or other documentation) of certification for the work.

- Nails to be used with wood members of l-l/2 inch thickness will be approximately 3 inches long. Nails must penetrate the concrete at least l-3/8 inches.

- The nail shear value will be reduced for any nail where the head penetrates more than l/8 inch into the wood or where the head is l/8 inch or more above the wood surface. The reduction shall be 25 percent (100 pounds) for each l/8 inch increment of length in excess of the l/8 inch limiting length. A corresponding reduction will be made for nails driven into air pocket voids.

- Nails shall not be driven within 3 inches of any concrete edge, nor within 3 inches of visible cracks in the concrete surface.

- Minimum end and edge distances for wood members shall not be less than required by Division policy for nailed connections. (See Chapter 4.) Nail spacing shall not be less than 6 inches.

9-1.10 Cable Bracing Systems

Cable bracing systems require thorough inspection to ensure that the type of cable used and the field installation conform to the details shown on the approved falsework drawings.

Prior to installation, the cable should be examined to verify that the size and type of the cable and its condition (new or used) is consistent with design assumptions. Used cable should be inspected for strength-reducing flaws. The use of obviously worn, frayed, kinked or corroded cable should not be permitted.

Cables must be looped around an appropriately sized thimble (or equivalent diameter steel pin) as recommended by the cable manufacturer.[8]

The following tabulation may be used to determine the required thimble diameter for a given cable size:

Cable Diameter	Approximate Standard Thimble Diameter
l/4 (Inches)	11/16 (Inches)
3/8	15/16
1/2	l/8
5/8	1 3/8
3/4	1 5/8
7/8	1 7/8
1	2 l/2

Cables looped around thimbles (or around an equivalent diameter anchoring device) are usually connected to the working part of the cable by Crosby-type wire rope clips. Clip installation should be carefully inspected, since properly installed clips are critical to the effectiveness of a cable system.

Table 4-3 (in Chapter 4) shows the proper method of installing Crosby clips. Additionally, keep in mind that although the efficiency factor for Crosby clips is 80 percent, this value is valid bnly when the clip is properly torqued in accordance with the manufacturer's recommendation.[9]

---

[8]Division policy provides for an exception to this general requirement in the case of cable looped around a timber cap where wood crushing will form an adequate radius for the cable connection. This exception, however, applies only to temporary bracing used during erection and removal, and permanent bracing used to event overturning in the longitudinal direction.

[9] Tests to system failure have shown that clips that are not properly torqued will slip before the cable breaks.

To ensure adequate holding strength, field engineers should review the clip installation procedure recommended by the manufacturer before work begins. [10]

As shown in Table 4-3, forged clips have greater holding strength, so fewer clips are required for a given installation. Forged clips are marked "forged" for positive identification, and have the appearance of galvanized metal, whereas malleable cable clips appear smooth and shiny.

The method by which the cable will be attached to the falsework and the location of attachment will be shown on the falsework drawings. No deviation should be permitted.

9-1.10A Preloading Cable for Internal Cable Bracing Systems [11]

When cable is used as diagonal bracing to prevent the collapse of a falsework bent, the cables must be preloaded to remove any slack in the cable and connections. Preloading is necessary to ensure that the cable units (i.e., all cables acting to resist forces in the same direction) will act elastically when loaded.

The required preload values for all cable units will be shown on the falsework drawings.

Applying the preload force is an essential part of the cable system installation, and the contractor must provide a means to verify or demonstrate that the required preload force has been applied. A method used by some contractors determines the preload force by measuring the elastic elongation within a short length of the cable. Measurements are made between tape bands placed around the cable to be preloaded. Measurements between the tape bands should be done after removal of any initial slack and again after the cable unit has been preloaded. [12]

When this procedure is used, keep in mind that the elongation calculation must be based on the reduced value of E, since the

---

[10] The contractor should be requested to furnish technical information from the manufacturer showing the installation procedure, recommended torque values, and other pertinent data prior to beginning erection of any cable system.

[11] The term "cable" as used in this section includes prestressing strand when prestressing strand is used as internal cable bracing.

[12] The term "initial slack" refers to excessively large loops at the connections or any excessive drape remaining the cable after installation. The initial slack must be taken up before the preload force is applied.

preload force represents only a small percentage of the cable strength. In addition, unless a prestretched cable is being used, constructional stretch may be a factor for consideration as well. (See "Determining Cable Elongation" in Chapter 4.)

The contractor may employ other methods to demonstrate that the correct preload force is being applied; however, the method must be accurate, readily verifiable, and must not rely on subjective considerations. Regardless of the method used, measurements to verify preload values are to be performed by the contractor in the presence of the engineer.

All cable units must be preloaded simultaneously to prevent frame distortion as the preload force is applied.

Preload tensioning devices must provide positive grip so that no cable movement will occur after final tensioning. Preloading can be done with turnbuckles or with come-a-longs.[13]

When cables are attached to timber members with an appropriate fastening device, the preload force must be applied twice. The first tensioning will permit the cable fastening device to bite into the wood. Following this initial tensioning, the cable should be unloaded and then retensioned to the required preload force. (Note that any additional wood crushing at the point of attachment will be minor and may be neglected in the analysis.)

Since preload force and cable drape are proportional for a given cable system, knowing the expected cable drape over a range of preload values gives the engineer a method by which the preload force actually applied may be approximated by visual inspection after the bent is erected. (For example, assume that for a particular cable a preload force of 500, 1000 and 1500 pounds results in a calculated drape of 1-1/2, 3/4 and 1/2 inches, respectively. From the relationship between drape and preload force, the engineer can readily determine the preload force actually applied.)

9-1.11 Traffic Openings

For falsework at traffic openings, the specifications require that components of the falsework system "...which contribute to horizontal stability and resistance to impact, except for bolts in bracing, shall be installed at the time each element of the falsework is erected and shall remain in place until the falsework is removed." (See Standard Specification Section 51-1.06B, Falsework Construction.)

[13] "Come-a-long" is a slang term for a Lug-all lever or ratchet hoist.

For administration of this specification requirement, Division policy provides as follows:

- The specification applies to the connections that provide lateral restraint at the base of the falsework post, to the connections at the top of the post between the post and cap, and to the connections between cap and stringer.

- The specification applies to permanent diagonal bracing (because such bracing contributes to horizontal stability) except that, at the contractor's option, connections may be nailed rather than bolted to facilitate adjustment of the falsework bent to grade. Nailed connections, when used in lieu of bolts, must provide the same capacity as the permanent bolted connection. The permanent bolted connection should be installed as soon as feasible.

- If traffic is being detoured during falsework erection, the components covered by the specification need not be installed as the falsework is erected. However, all such components must be installed before traffic is allowed to pass adjacent to or under the falsework.

Horizontal and vertical clearances should be measured to verify compliance with contract requirements as soon as the bents are erected and the beams set in place. Actual clearances should be recorded in the job records.[14]

Anticipated vertical clearance restrictions should have been reported to the District pursuant to the instructions in Bridge Construction Memo 2-ll.O. Any changes occurring as the falsework is erected should be reported immediately to the resident engineer and/or District permit engineer.

9-1.llA Falsework Lighting at Traffic Openings

General requirements for pavement and portal lighting at traffic openings, including openings for pedestrian walkways, are found in Section 86-6.11, Falsework Lighting, of the Standard Specifications. Any project specific requirements will be shown on the plans or included in the special provisions.

---

[14]Keep in mind that the actual vertical clearance provided when the falsework is first erected must included an allowance for beam deflection, and falsework settlement that will occur as the concrete is placed.

The contractor must submit a lighting plan showing all details of the falsework lighting system. The falsework lighting plan must be approved by the engineer before falsework construction at the traffic opening may be started?

The lighting plan should be reviewed from the viewpoint of public traffic, and for employee safety during routine maintenance work as well. (Keep in mind that the specifications do not permit closing of traffic lanes for routine maintenance of the lighting system on any roadway having a posted speed limit above 25 miles per hour.)

All features of the portal illumination, including plywood clearance markers, as well as pavement and pedestrian walkway lighting if required, must be in place and operational before any beams are set over the traffic opening.

As soon as the falsework is erected and the lights turned on, the lighted falsework opening should be inspected after dark to check the effectiveness of the lighting, and the lights moved or adjusted if necessary to provide uniform illumination. Nighttime inspection should continue periodically, as lights may be inadvertently moved or disturbed as construction continues. An inspection during adverse weather, such as rain or fog, is also advisable.

Temporary K-rail and all painted surfaces at the portal opening must be maintained in a clean, white condition. Repainting, if necessary, may be paid for as extra work.

9-1.12 Field Changes

As provided in the specifications, "...falsework shall be constructed to substantially conform to the falsework drawings." (Section 5l-l-06B Falsework Construction, of the Standard Specifications.)

Determining whether the falsework as actually constructed "substantially" conforms to the drawings is a matter of engineering judgment. As a policy consideration, minor deviations to suit field conditions or the availability of materials will be permitted if it is evident by casual inspection that the change neither increases the stress in, nor the deflection of, any

---

[15] The falsework lighting plan is not part of the falsework drawing-submittal covered by Section 51-1.06, Falsework, of the Standard Specifications. It is a separate submittal, which is reviewed-and approved pursuant to Standard Specification 5-l.02, Plans and Working drawings. However, if the lighting plan is shown on the falsework drawings, approval of the drawings will constitute approval of the lighting plan as well.

falsework member beyond the maximum value allowed, nor reduces the load-carrying capacity of the falsework system as a whole. Such changes need not be shown on revised drawings; however, they should be noted on the structure representative+ copy of the approved drawings.

If calculations are necessary to verify compliance with contract requirements, the change will be considered substantial and revised drawings, with calculations, will be required.

Revised drawings must be submitted for review in the same manner as the original drawings. In many cases the change can be shown on a simple sketch on letter size paper, while other changes, depending on their magnitude, may require total revision of an original drawing. Keep in mind that if a change is shown on a sketch; the sketch must be signed and stamped by a registered civil engineer, and that calculations are required in all cases.

Division policy provides that drawings or sketches showing changes made during construction will be given a high review priority, although contractually such changes constitute design revisions following approval, so that the review time allowed is the same as allowed for the original design review.

Work shown on a revised falsework drawing or sketch may not begin until that drawing has been approved by the engineer.

Any change in the approved falsework design, however minor it may appear to be, has the potential to adversely affect the structural integrity of the falsework system. Therefore, before approving any change, the engineer should ask, and then answer to his satisfaction, the question: "How does this change affect the falsework system as a whole?"

9-1.13 Cal-OSHA Requirements

Article 1503 of the *Construction Safety Orders* requires the contractor to obtain a permit to construct or remove falsework or shoring that is more than three stories high, This requirement is discussed in Chapter 2, and reference is made thereto.

Article 1717 of the *Construction Safety Orders* requires all falsework or vertical shoring systems to be inspected and certified prior to concrete placement. The certification must be in writing, and it must state-that the falsework, as constructed, substantially conforms to the working drawings and that the materials and workmanship are satisfactory for the purpose intended.

For falsework or shoring which exceeds 14 feet in height, measured from the top of the foundation to the superstructure soffit, or where the length of an individual span exceeds 16 feet, or where provision is made for the passage of vehicular or railroad traffic through the falsework or shoring, the required inspection and certification must be made by a civil engineer registered in California, or by his authorized representative.

For all other falsework; the inspection and certification may be made by any one of the following:

- a civil engineer registered in California.
- for shoring systems, a manufacturer's authorized representative.
- a licensed contractor's representative qualified in the usage and erection of falsework and vertical shoring.

Arranging for the required inspection and certification is the contractor's responsibility. When the falsework design is such as to require inspection and certification by a registered civil engineer, it is the contractor's engineer who assumes this responsibility. However, the structure representative will verify that the falsework has been inspected by examining the certificate and noting its existence in the project diary. It is not necessary to obtain a copy of the certification for the job records.

Inspection and certification of the falsework pursuant to the requirements in Article 1717 of the *Construction Safety Orders* does not relieve the contractor of any of his responsibilities under the contract for falsework construction, nor does it relieve the structure representative of his responsibilities with respect to contract administration. Even though the falsework is certified by the contractor's engineer or by other appropriate authority, the structure representative must satisfy himself that the falsework has been constructed in conformance with the approved falsework drawings before permitting the contractor to place concrete.

9-1.14 Inspection During Concrete Placement

As concrete is being placed, the falsework should be inspected at frequent intervals. In particular, look for the following indicators of incipient failure:

- Excessive compression at the tops and bottoms of *posts* and under the ends of stringers; crushing of wedges.
- Movement or deflection of diagonal bracing; distortion at connections; pulling of nails.

- Tilting or rotation of joists or stringers; excessive deflection of any horizontal member.
- Posts or towers that are bowing or moving out of plumb.
- Excessive settlement as indicated by telltales,
- The sound of falling concrete or breaking timbers; any unusual sound.

The specifications limit falsework settlement to a maximum of 3/8 inch deviation. from the anticipated settlement shown on the falsework drawings. Telltales should be monitored as concrete is placed, and should the actual settlement exceed the predicted settlement by more than the allowable deviation, concrete placement in the affected area should be discontinued and the cause of the excessive settlement investigated. Concrete placement should not be resumed until the engineer is satisfied that further settlement will not occur. (Keep in mind that settlement due to soil compression may continue for some length of time, even though the load is not increased.)

If settlement continues, or if inspection reveals falsework members in distress (such as crushing at joints, rotation or tilting of vertical members, or any similar indication of incipient failure) all concrete placement should be stopped immediately, and the falsework strengthened by the installation of supplementary supports, or by some other means.[16]

9-1.15 Inspection After Concrete Placement

Falsework inspection should not stop with concrete placement, but should continue periodically until the falsework has been completely removed.

One important and often overlooked point is the danger of curing water softening the falsework foundation. Some means should be provided to prevent curing water from reaching and soaking the foundation material beneath the falsework bearing pads.

The contractor should provide for drainage of rain or curing water that accumulates in the box girder cells. Such water in the cells could easily overstress the falsework or, if deep enough, the permanent structure as well.

---

[16] Reference is made to the Division's *Concrete Technology Manual* for a discussion of the factors to be considered when it becomes necessary to install an emergency construction joint.

9-1.15A Deck Shrinkage

Continuing inspection is particularly important in the case of post-tensioned structures because of the redistribution of dead load forces that occurs following the deck concrete pour. As the newly placed deck concrete shrinks during the curing period, the downward force exerted on the falsework by the bridge superstructure increases. The increase is greatest near the center of the structure span, and typically reaches its maximum from four to seven days after the deck concrete is placed.

The effect of deck shrinkage is of greater concern in cast-in-place prestressed structures than in conventionally reinforced concrete structures because post-tensioned structures have relatively little rigidity until they are stressed.

The effect of deck shrinkage is not addressed in the specifications, except indirectly for falsework adjacent to a traffic opening where the falsework posts must be designed to carry at least 150 percent of the theoretical load. However, field engineers should be aware of the potential problem and look for locations where the falsework may be adversely affected. [17]

9-1.16 Falsework Removal

Contract provisions governing falsework removal are found in Section 51-1.06C, Removing Falsework, of the Standard Specifications. This section contains specific benchmark criteria that must be met before any falsework may be released. In general, the falsework must remain in place for a specified time period, or until the concrete attains a specified strength, or for cast-in-place prestressed construction, until stressing (but not grouting) is completed.

Additionally, for continuous structures, the removal of falsework supporting a given span cannot begin until all required work (excluding concrete above the bridge deck and grouting of prestressing ducts) has been completed in that span and in the adjacent spans over a length equal to at least 1/2 of the length of the span where falsework is to be removed. See Figure 9-l.

---

[17] As a point of interest, field research conducted in the early 1970's revealed that -- depending on falsework configuration, type of structure and construction sequence -- the maximum load imposed on the falsework varied from as little as 110 percent to as much as 200 percent of the load measured about 24 hours after deck concrete placement. The 150 percent figure in the specifications is a compromise that recognizes that some increase will occur in virtually all instances.

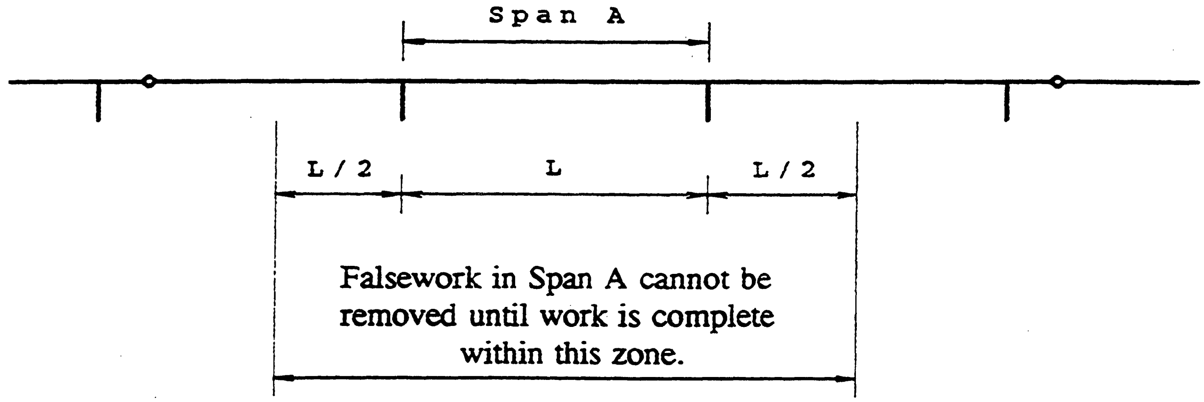

FIGURE 9-1

Falsework removal often presents a greater challenge than the original construction; hence it must be carefully performed to ensure both worker and public safety. To ensure that falsework removal receives the attention it warrants, the specifications require the contractor to include a removal plan on the falsework drawings. The plan must show the methods and procedures to be employed, and any temporary bracing required.

When evaluating falsework removal schemes, keep in mind that the stability of the falsework system depends on the interaction of many component parts. As falsework components are removed, unbalanced and/or eccentric loadings may occur, and the use of jacks to unload portions of the falsework may induce forces that exceed those considered in the original design. No stabilizing component should be removed without considering the effect of its removal on the stability of the falsework still in place.

Since the falsework removal plan must be shown on the falsework drawings, it must of necessity be developed many months (even years on very large projects) before the actual removal work will be done, and thus its appropriateness may be affected by conditions and circumstances that were not anticipated. In view of this reality, prior to the start of any falsework removal, the structure representative along with staff members who may be directly involved with the removal operation are to meet with the contractor to review the removal plan. The review should consider the general appropriateness of the removal method in the light of the actual site conditions, and should include a discussion of the removal sequence and equipment to be used, the number and responsibilities of the workers involved, and public and worker safety.

INSPECTION

The contractor must designate an employee who will be in charge. of the removal work, and who will be present at the work site while the work is in progress. Additionally, the structure representative will assign a staff member to be present whenever falsework is being removed. However, field personnel should keep in mind that falsework removal, like all other contract work, is the contractor's operation and it is the contractor's responsibility to perform the work in a safe manner and in accordance with the approved removal plan.

Some contractors use cables attached to winches set on the bridge deck to lower elements of the falsework system. While this is a simple and generally satisfactory removal method, the weight of the winch plus the weight of the suspended falsework may produce a relatively large concentrated load. Before such removal plans are approved, the structure representative should be certain that the winch load is distributed over the deck in a manner that prevents overstressing of the permanent structure, In some cases it may be appropriate to discuss the distribution method with the designer.

Division of Structures policy provides for an exception to the specification provisions governing release of falsework in the case of bracing system components. With certain exceptions as discussed in the following paragraph, bracing components may be removed on the day following deck concrete placement if, in the structure representative's judgment, theconcrete superstructure is capable of transferring horizontal forces from the falsework to the bridge substructure.

Bracing must remain in place until all other falsework may be removed in the following cases:

- For all falsework, all elements of cable bracing systems installed to prevent internal collapse of a falsework bent must remain in place.

- Bracing or other methods used to support the compression flange of a beam or reduce the L/d ratio of any falsework member must remain in place until the other elements of the falsework system are removed.

- For falsework erected over or adjacent to roadways or railroads, all components that contribute to horizonal stability and resistance to impact must remain in place until the elements of the system they are restraining are removed. This includes diagonal bracing as well as the special impact resisting connections.

- For falsework supporting continuous prestressed structures being constructed in stages, bracing must remain in place as discussed in the following section.

9-l.16A Stage Construction

When continuous cast-in-place prestressed structures are constructed in stages, the stage construction sequence will require some load-supporting elements of the falsework system to remain in place for an extended period of time. For such structures, falsework removal involves special considerations.

For any given construction stage, the initial stressing will transfer the superstructure dead load from the center of the spans toward the points of support. This redistribution of dead load forces will decrease the load applied to the falsework near the center of the continuous spans. The load being carried by falsework near the center of a suspended span will be decreased as well; however, the load on the falsework supporting the hinge or construction joint will be increased by dead load transfer.

For continuous prestressed structures, the specified sequence of falsework removal will require certain elements of the falsework system to remain in place. Except for any bracing installed to prevent overturning, all components of such falsework, including diagonal bracing, must remain in place, even though the falsework may have been partially unloaded by the prestressing operation. This procedure is necessary because, with the passage of time, the redistributed dead load will be carried back toward the center of the span as superstructure dead load deflection takes place.

For continuous prestressed structures, all elements of the falsework system that are not required by the specifications to remain in place should be completely removed. If the falsework cannot be removed within a reasonable time, any components remaining in place should be unloaded. This procedure is necessary to prevent overloading of partly disassembled falsework still in place under the deflecting superstructure.